Representation of Verbal Inflections in Native and Non-native French: Evidence from a Masked-Priming Word-Naming Task

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1. Introduction

One question that has received much attention in recent second/foreign language (L2) research is how verbal morphology is stored and processed by L2 learners. Recent studies have found that while first language/native (L1) speakers of a given language rely on two distinct mechanisms to process regular and irregular verb forms, non-native speakers show variability in their ability to use these two mechanisms (e.g., Bowden, Gelfand, Sanz, & Ullman, 2010; Diependale, Duñabeitia, Morris, & Keuleers, 2011; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008; Ullman, 2001a, 2001b). For native speakers, regularly inflected verb forms have been argued to be computed from a stem and an affix (e.g., *walk*+*ed*) in the procedural memory system, whereas irregularly inflected verb forms have been proposed to be stored in their whole form (e.g., *went*) in the declarative memory system (e.g., Paradis, 2004, 2009; Ullman, 2001, 2004). Many studies have shown that native speakers can access both of these memory systems, but non-native speakers may not be able to use procedural memory, and thus are forced to rely on declarative memory and store regularly inflected forms in their whole form (e.g., Clahsen & Felser, 2006; for a review, see Clahsen et al., 2010).

The objectives of present study are twofold: (i) to investigate the mental representation of inflected verbal forms in native and non-native French speakers who began learning French after the age of 10; and (ii) to determine if a word-naming task may be a more sensitive methodology to study L2 decomposition. The paper is organized as follows: Section 2 provides a brief literature review of recent research on L2 learners' processing of inflectional morphology; Section 3 describes the specific methods used in this research; Section 4 presents the results; and Section 5 discusses these results and their implications for understanding L2 morphological processing, and concludes the paper.

2. L2 Inflectional Morphology

Much research suggests that native speakers rely on two distinct memory systems to represent regular and irregular verb forms: declarative memory and procedural memory. Declarative memory has been proposed to be associated with learning arbitrary information, including the learning of a particular irregular verb form and its associated tense or agreement feature (e.g., *went*); by contrast, procedural memory has been claimed to be associated with computing sequences, such as composing a regular, morphologically complex word from a stem and an affix (e.g., *walk*+*ed*) (e.g., Paradis, 2004, 2009; Pinker, 1998; Ullman, 2001, 2004). Whereas many studies have demonstrated that native speakers use these two memory systems (e.g., Alegre & Gordon, 1999; Marslen-Wilson& Tyler, 1998; Münte, Say, Clahsen, Schiltz, & Kutas, 1999; Pinker & Ullman, 2002; Prado & Ullman, 2009), the conditions under which non-native speakers use declarative vs. procedural memory remain unclear.

Many studies investigating this question have used as diagnosis the effect of frequency on word recognition. The rationale for using frequency effects is that regular and irregular verb forms should show differences in how their surface-form frequency affects lexical decision if they are processed in

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different memory systems: irregular verb forms stored in their whole form are expected to be identified more quickly with increasing frequency, whereas regular verb forms that are decomposed should only show stem frequency effects, not surface form effects (for L1 processing studies that used this method, see e.g. Beck, 1997; Lalleman, van Saten, & van Heuven, 1997; Prado & Ullman, 2009). Neubauer and Clahsen (2009) used frequency effects in a lexical decision task to study the representation of past participles by L1 Polish L2 German speakers at high L2 proficiency. They found that native speakers showed the expected frequency effects only for irregular past participles (e.g., ge*rufen* 'called'), whereas the non-native speakers showed frequency effects for both regular and irregular past participles (e.g., ge*meldet* 'reported' and ge*rufen* 'called') This was considered as evidence that L2 learners do not decompose inflected forms into stem and affix, but rather store them as a whole.

Another method that has been used to investigate morphological processing is masked-priming. In such studies, the participants see a masked prime for a very brief amount of time (e.g., 50 ms) followed by a target word. These studies typically include three conditions: (i) an identity condition where the prime and the target are the exact same word (e.g., *speak-SPEAK*); latencies in this condition show the maximum amount of priming possible; (ii) an unrelated condition where the prime and the target are completely unrelated words (e.g., *watch-SPEAK*); this condition shows the minimum amount of priming possible; and (iii) a test condition where the prime and target are the same word, but one is inflected and the other is not (e.g., *speaking-SPEAK*). The rationale behind using such a methodology is that if the recognition of a stem target is equally facilitated by the appearance of the corresponding inflected prime (i.e., (iii)) and by the appearance of the same stem prime (i.e., (i)), and more so than by the appearance of an unrelated stem prime (i.e., (ii)), then it can be deduced that the inflected prime was decomposed into its stem and affix components (e.g., Fiorentino & Fund-Reznicek, 2009; Marslen-Wilson & Tyler, 1998; Silva & Clahsen, 2009; Sonnenstuhl, Eisenbeiss and Clahsen, 1999).[1]

In their second experiment, a masked-priming lexical decision task, Neubauer and Clahsen (2009) found that while their L1 German group showed full priming for regularly inflected past participles (e.g., *geleistet* 'achieved'), the L1 Polish L2 German group showed no priming effects at all in the inflected prime condition. That is, the L2 learners were slower at identifying the target when the prime was the inflected form than when it was the exact same word, and they were equally slow when the prime was an inflected form as when it was an unrelated verb. Similar results were found for regular English past tense morphology (e.g., *kicked*) in Silva and Clahsen's (2008) study with L1 Chinese and L1 German L2 English speakers at high L2 proficiencies. In their discussion of these (and other) L2 morphological processing studies, Clahsen et al. (2010) conclude that L2 learners are less sensitive to morphological structure and rely more heavily on whole word storage than native speakers do. The conclusions drawn in Clahsen et al. (2010) are consistent with Clahsen and Felser's (2006) Shallow Structure Hypothesis, which claims that L2 learners are less sensitive to structural information than native speakers, irrespective of L2 proficiency.

The masked-priming lexical decision paradigm has been used in many studies to evaluate L2 decomposition. Yet, it is possible that the task itself is not sufficiently sensitive to capture L2 morphological processing. It has been claimed that such a task requires not only lexical access, but also post-lexical processing in deciding whether the target is a word (e.g., Balota & Chumbley, 1984; Monsell, Doyle, & Haggard, 1989; Seidenberg, Waters, Sanders, & Langer, 1984). This decision process (which is independent from decomposition) may well be obscuring potential evidence of decomposition. Additionally, it has been proposed that lexical-decision paradigms encourage whole-word access over rules for regularly inflected words, whereas production tasks may encourage the use of both rules and whole-word storage (Pinker, 1999).

Ullman and colleagues (e.g., Bowden et al., 2010; Ullman, 2001b) posit that L2 learners may be able to rely on procedural memory more with increased exposure to the L2. Bowden et al. (2010) conducted a speeded production task in L1 and L2 Spanish. Participants saw a verb in its infinitive form from three verb classes and were instructed to say the word aloud in either the present or

[1] Note that the target is exactly the same word in these tasks; it is the prime, not the target, that is manipulated. There is thus no reason to expect longer reaction times for the target word if the inflected prime is decomposed into stem and affix.

imperfect form; production latencies were recorded. The results showed that whereas native speakers' production latencies were affected by the surface frequency of the produced form for all verb classes other than regularly inflected verbs, the L2 learners showed frequency effects in all conditions. They concluded that the learners stored both regularly and irregularly inflected forms in their whole form, whereas natives composed regular forms from stem and affix. The authors, however, note that the learners had little immersion experience, so it is possible that immersion and greater proficiency enable L2 learners to decompose inflected words. In other words, a shift of memory system reliance from declarative to procedural memory may happen as L2 proficiency increases.

Recent neurolinguistic studies suggest that L2 learners may indeed go from treating regularly inflected forms as whole lexical forms to decomposing them into stem and affix and thus treating them as morphosyntactic forms. However, the method of learning and proficiency in specific domains may be of critical importance in being able to pattern like native speakers. Morgan-Short (2007) demonstrated that implicit learning (resembling immersion learning), but not explicit instruction, allowed L2 learners to show native-like processing of morphology in Event-Related Potentials (ERPs). As she suggests, her results are consistent with the declarative/procedural model (Ullman, 2001) in that the underlying processes of the implicit group are what would be expected from utilizing procedural memory. However, this study used the artificial language BROCANTO 2; hence, one might question whether the findings of this study generalize to real language learning. Hahne et al (2006), however, also examined the ERPs of native German speakers and Russian L2 learners of German as they processed incorrect regularization (e.g., **gelauft "run"*) and irregularization of German verbs and plural nouns. The results show that L2 learners treated both types of violations differently, with regularization eliciting a P600 effect and irregularization eliciting an N400 effect. These results suggest that L2 learners can indeed show different processing signatures for regularly and irregularly inflected words. Yet, decomposition may be less automatic in the L2, and it may be available only for L2 learners who are sufficiently proficient in specific domains (e.g., participle formation).

The present study investigates the conditions under which L2 learners show evidence of morphological decomposition. It uses a different methodology that may prove more sensitive to decomposition. Unlike much of the previous research on this topic, this study uses a speeded masked-priming word-naming task to look at regular-verb decomposition. Because word naming does not involve post-lexical processes that are not related to the decomposition task (such as deciding whether the word exists), a masked-priming word-naming task may show more sensitivity to different types of primes as compared to a lexical decision task. Whereas most L2 masked-priming studies use inflected primes and stem targets, this study includes both stem and inflected primes and targets. The motivation for including both prime and target types is that it allows for decomposition to happen in two different places: when the participants (unconsciously) read the prime and when they read the target.

Recall that Clahsen and colleagues posit a qualitative difference between native and L2 morphological processing, irrespective of L2 proficiency. If this theory is correct, in the present study L2 learners should show no priming effects in the test conditions. This would mean that L2 learners' production latencies in the test conditions should not be different from those in the unrelated conditions, and both of these conditions have longer latencies than the identity condition. On the other hand, the theory advocated by Ullman and colleagues predicts a qualitative shift in L2 morphological processing, with L2 learners being qualitatively different from native speakers at lower proficiency levels but not at higher proficiency levels. If this theory is correct, in this study L2 learners' word-naming latencies in the test conditions should not be different from those in the identity conditions, at least for high-level L2 learners.

3. Method

3.1. Participants

The participants in this study were 17 native English speakers (ages 20-32) who learned French as adults, and 4 native speakers of European French (ages 20-27). All learners of French grew up speaking only English until age 10 and all native French speakers grew up speaking only French until age 10. All participants were tested in a Midwestern American institution. The learners of French included graduate and undergraduate students enrolled in at least one French class at the time of testing, which ensured that they were currently using French on a regular basis. Participants were either paid or given extra credit in their French class for their participation.

All participants completed a language background questionnaire providing biographical information about their language learning experience. For L2 learners, this information included their age of first exposure to French, number of years of instruction in French, number of months of residence in a French-speaking environment, and percent weekly use of French. Furthermore, all L2 learners completed a cloze test that assessed their global proficiency in French (for more information about the particular test that was used, see Tremblay, 2011; Tremblay & Garrison, 2010). Table 1 presents the L2 learners' cloze test scores and language background information. As is seen in Table 1, the learners did not form a homogenous group, with participants ranging from mid-level proficiency (12-25) to high-level proficiency (26 and above).[2] The high-level learners who scored higher than 25 on the cloze test were all graduate students in a French department, whereas the mid-level learners were mostly undergraduate students from a variety of departments.

Table 1
Language Background Information and Cloze Test Scores of the L2 Learners

	Cloze Test Scores (/45)	Age of First Exposure to French	Years of French Instruction	Months of Residence in a French-Speaking Environment
Mean	26.25	13.2	9.4	8.5
SD	7	2.8	3.1	11.4
Range	12-38	10-22	5-16	0-34

3.2. Materials

The experimental items were 96 regular *–er* French verbs. There were three prime conditions (identity, test, unrelated) with two target types (stem and inflected) each, giving a total of six conditions for each verb. In the identity condition, the target word and the prime were the exact same form; in the test condition, the target and the prime were the same verb but in different inflectional forms; and in the unrelated condition, target and prime were phonologically and semantically unrelated verbs but had the same inflection as the target verb. The average word length was 6.6 letters and 1.7 syllables for stem targets, and 7.8 letters and 2.4 syllables for inflected targets. Additionally, the average surface-form frequency, established from the Lexique database (www.lexique.com; New, Pallier, Ferrand, & Matos, 2001) was 32.23 (per million words) for stem targets and 5.82 (per million words) for inflected targets. Hence, an effect of target type (if any) could potentially be due word length and frequency differences between stem and inflected targets.

All primes were presented in lowercase letters in size 14 font, and all target words were presented in capital letters in size 18 font. The font size of the prime differs from that of the target because it was visually distracting when they were the same size, allowing participants to be aware that something was happening on the screen before the target word. Both fonts were easily read at their respective sizes, and transition from mask to prime to target was undetectable to participants with these sizes.

An example for each of the six conditions is shown in Table 2. Note, however, that six lists were used so that no participant would see any experimental item in more than one condition. The materials also included 192 filler items, all of which consisted of real French nouns presented with either an identical prime or an unrelated noun prime.

[2] Native French speakers, who were tested when the cloze test was piloted, obtained scores over 40 out of 45 (A. Tremblay, personal communication August 1, 2012).

Table 2
Example Stimuli for parler ('to speak') in the Six Experimental Conditions

Target/Prime	Identity	Test	Control
PARLE 'speak'	parle 'speak'	parlons 'speak-1stpers.pl'	donne 'give'
PARLONS 'speak'	parlons 'speak-1stpers.pl'	parle 'speak'	donnons 'give'

3.3. Procedure

The experiment was administered using E-Prime 1.2 (Psychology Software Tools; Schneider, Eschman, & Zuccolotto, 2002). The participants were told they would be producing French words in isolation as they appeared on the computer screen, and that they should say them as quickly as possible. They were instructed not to correct themselves if they made a mistake. A row of pound signs (########) first appeared on the screen for 750 ms, followed by the prime word for 50 ms (faster than the threshold of perception) and then the target word. The pound signs served as a mask to make the prime more difficult to see. The participants heard a beep as the target word appeared on the screen. The target remained on the screen for 2000 ms, and the next test item began thereafter. The items in the six lists were pseudo-randomized such that words in the experimental condition would not appear more than twice in a row, and they were randomized across participants so that each participant would see the test items in a different order. Periodically throughout the experiment, a screen saying *PLUS VITE!* 'faster!' reminded the participants to respond as quickly as possible. The beep that marked each word onset and the participants' responses were recorded via a head-mounted microphone that the participant wore.

The experiment began with a practice session of 8 items. The main session was broken into four equal blocks of items and the participants were told they could take a break between blocks if they became fatigued. The participants took approximately 12 minutes to complete the experiment. The language background questionnaire and the cloze test were completed after the experiment. The complete session took approximately 20 minutes for native French speakers (who did not complete the cloze test) and 45 minutes for the L2 learners.

3.4. Data Analysis

Word-naming latencies were the dependent variable in this experiment. Using the software Praat (www.praat.org; Boersma & Weenink, 2007), for each experimental item produced by each participant, the time between the offset of the beep (indicating the appearance of the target word) and the onset of the production was measured in milliseconds. These measurements were then extracted with a script for further analysis. Mean latency was calculated for each subject, and any latency greater than 2.5 SD above the mean was removed. Additionally, false starts and production errors were excluded. This excluded 6% of the learner data and 9.6% of native speaker data.

Word-naming latencies were analyzed with linear mixed-effects models using R (for details, see Baayen, 2008). Given the uneven number of participants in each group, separate models were used for native speakers and L2 learners. These models included subject and item as random variables. Additionally, they included the following fixed variables: target type (stem, inflected), prime type (identity, test, unrelated), target surface-form frequency (extracted from www.lexique.org; New, Pallier, Ferrand, & Matos, 2001), target syllable count, and cloze test score (only for the learner model). Frequency and target syllable count were included in the models in order to determine whether an effect of target type, if any, would remain significant if frequency and target syllable count were controlled for. Simple and interaction effects that were not significant and did not improve the model were removed. In the first set of models, the unrelated condition was treated as the baseline, with test and identity conditions being compared to it; in the second set of models, the identity condition was treated as the baseline, with test and unrelated conditions being compared to it.

4. Results

Table 3 shows the word-naming latencies for each condition for both native and non-native French speakers.

Table 3
Production Latencies (Standard Deviation) in Milliseconds for Native Speakers and L2 Learners

Target Type	Stem			Inflected		
Prime Type	Identity	Test	Unrelated	Identity	Test	Unrelated
Native French (n=4)	331 (122)	332 (75)	375 (85)	328 (83)	333 (82)	387 (102)
L2 Learners (n=17)	447 (138)	460 (132)	473 (131)	486 (141)	487 (135)	520 (141)

For native speakers, the final model with the unrelated condition as baseline revealed a significant effect of prime type for both the test condition, $t(344)= -4.768$, $p<.001$, and the identity condition, $t(344)= -5.121$, $p<.001$, and a significant effect of target syllable count, $t(344)= 4.445$, $p<.001$; no interaction was significant. These results indicate that the native speakers' latencies were faster in the test and identity conditions than they were in the unrelated condition, and they increased as syllable count increased.

Also for native speakers, the final model with the identity condition as baseline revealed a significant effect of prime type in the unrelated condition, $t(344)= 5.121$, $p<.001$, a significant effect of target type, $t(344)= -2.173$, $p<.05$, a significant interaction between priming in the test condition and the effect of target type, $t(344)= 2.635$, $p<.05$, and a significant effect of target syllable count, $t(344)= 4.445$, $p<.001$; no other interaction was significant. Because there was an interaction between test prime and target type, stem and inflected targets were subsequently analyzed separately. Again, using the identity condition as baseline, for stem targets there was a significant effect of unrelated prime, $t(171)= 2.831$, $p<.01$, and a significant effect of target syllable count, $t(171)= 3.245$, $p<.01$; for inflected targets, there was a significant effect of unrelated prime, $t(172)= 4.404$, $p<.001$, and a significant effect of target syllable count, $t(172)= 2.926$, $p<.01$. This suggests that the priming effect may be larger for inflected targets than for prime targets, but for either target, latencies in the test condition did not differ from those in the identity condition, but they differed from those in the identity condition. Additionally, targets with more syllables elicited longer latencies than targets with fewer syllables. Critically, this effect did not interact with the effect of prime type.

For L2 learners, the final model with the unrelated condition as baseline revealed a significant effect of prime type for both the test condition, $t(1530)= -3.733$, $p<.001$, and the identity condition, $t(1530)= -5.130$, $p<.001$, and a significant effect of number of target syllables, $t(1530)= 5.854$, $p<.001$; no other effect or interaction was significant. These results confirm that L2 learners' latencies in the unrelated conditions were longer than their latencies in both the identity and test conditions irrespective of proficiency, and that latencies increased with higher target syllable count. Importantly, the effect of syllable count did not interact with the effect of prime type.

Also for L2 learners, the final model with the identity condition as baseline revealed a significant effect of prime type for the unrelated condition, $t(1530)= 5.127$, $p<001$, but not for the test condition $t(1530)= 1.579$, $p>.1$; no other effect or interaction was significant. These results show that L2 learners' latencies in the test condition were not different from those in the identity condition, and they both differed from the latencies in the unrelated condition, irrespective of proficiency.

The above results indicate that both native speakers and L2 learners show evidence of full priming in their latencies, suggesting that they decompose regularly inflected verbs. Importantly, decomposition did not appear to vary with L2 proficiency, as the effects of priming observed did not interact with proficiency.

5. Discussion and Conclusion

This paper aimed to investigate the representation of regularly inflected verbs in non-native French, and determine if a speeded masked-priming word-naming task is a better way to investigate L2 decomposition. The results of this study suggest that, like native speakers, non-native speakers may in fact use procedural memory in the L2, as suggested by the full priming effects for the L2 learner group. Recall that full priming is evidenced when the participants show similar latencies in the identity and test conditions but different latencies between the test and unrelated conditions. Interestingly, the data do not show an effect of L2 proficiency or an interaction between proficiency and the fixed variables. This suggests that lower-level learners may be able to decompose regularly inflected verbs, unlike what has been found in previous studies that have used not only masked-priming (e.g., Bowden et al., 2010; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008), but also ERPs while processing inflectional morphology (e.g., Hahne et al., 2006). These findings indicate that the present methodology may be more sensitive to investigate L2 decomposition, in part because word naming does not involve post-lexical processes that are not related to the decomposition task (such as deciding whether the word exists). The results of this study are inconsistent with Clahsen's claim that there is a qualitative difference of L2 morphological processing (e.g., Clahsen & Felser, 2006). Instead, these results are more in line with Ullman's declarative/procedural model in that the learners in this study show evidence of decomposing inflected forms, which has been interpreted as evidence of using the procedural memory system. However, proficiency does not seem to contribute to this finding.

Other studies that used tasks other than masked-priming have shown that L2 learners at sufficiently advanced proficiencies have suggested that L2 learners can decompose morphologically complex words. For example, Birdsong and Flege (2001) examined L2 learners of English from many different L1s in a task where they selected the correct form of English past tense verbs that had different surface form frequencies. They found no frequency effect for regularly inflected verbs, which suggests sensitivity to the morphological structure of the words. The present results are also in line with those of Hahne et al. (2006), who showed that at highly proficient L1 Russian L2 German speakers demonstrated decomposition of regularly inflected participles. This indicates that L2 learners can decompose morphologically complex regular verbs, just like native speakers do, and that doing so can be achieved in a masked-priming task. Importantly, the present study showed no interaction between proficiency and priming, indicating that lower-level L2 learners showed the same priming effect as higher-level L2 learners. This suggests that decomposition may be possible at even lower levels of proficiency than previously thought (e.g., Bowden et al., 2010; Hahne et al., 2006).

While these results are very interesting, the study is not without limitations. Among other things, it is possible that the L2 learners in this study are in fact showing orthographic or semantic priming in the test conditions. That is, they may not activate the target word from the prime word, but from the orthographic or semantic overlap between the prime and target forms in the test conditions. Many L1 morphological processing studies, however, have failed to find evidence of orthographic or semantic overlap facilitation in masked-priming tasks (e.g. Allen & Badecker, 2002; Davis & Lupker, 2006; Longtin, Segui, & Hallé, 2003; Meunier & Marslen-Wilson, 2004). Additionally, if orthographic and semantic priming were pervasive, such effects would have been found in the L2 morphological processing studies conducted by Clahsen and colleagues (e.g., Neubauer & Clahsen, 2009; Silva & Clahsen, 2008). Further research that uses control conditions where the prime overlaps semantically or orthographically with the target word is necessary to confirm the nature of the priming effects found in the present study.

Overall, the present study suggests that L2 learners can decompose morphologically complex words. Word-naming latencies in a masked-priming task may provide a very promising measure for investigating the way in which L2 learners represent morphologically complex words.

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